DISK-RESOLVED SPECTRAL CHARACTERISTICS OF GANYMEDE AND CALLISTO

T. Denk[1], G. Neukum[1], P. Helfenstein[2], M.J.S. Belton[3], K.C. Bender[4], P. Geissler[5], R. Greeley[4], J.W. Head[6], R. Jaumann[1], R.T. Pappalardo[6], and the Galileo SSI Team. [1]DLR, Institute of Planetary Exploration, 12484 Berlin, Germany; [2]Cornell University, Ithaca, NY; [3]NOAO, Tucson, AZ; [4]ASU, Tempe, AZ; [5]LPL, Tucson, AZ; [6]Brown University, Providence, RI.

INTRODUCTION

During the C3 and G1 encounters, the Galileo SSI camera obtained global color images of Callisto (*Fig. 1a*) and Ganymede (*Fig. 1b*) in summation mode with a resolution of 10 and 13 km/pixel, respectively. The Ganymede images (SCLK no. 349632000 – 349632200) are centered at 6°S, 153°W and have been taken through six different color filters. The Callisto color data set (SCLK no. 368211900 – 368212000) contains cut-out windows of five different color images, centered at 15°N, 140°W. During the G2 encounter, a high-resolution 4-color observation of an unnamed dark-floor crater located at 2°N, 153°W in Ganymede's Uruk Sulcus has been achieved [1].

In general, the SSI color observations of the Galilean satellites have two primary goals: (1) Determination of the variety of materials on the surfaces, and (2) Determination and mapping of the spatial distribution of different materials (and/or grain sizes) and their mixing ratios. In comparison to the Galileo NIMS instrument, the advantage of SSI is its larger spatial coverage and better spatial resolution, while the spectral resolution and wavelength range of NIMS complement SSI.

CALLISTO

A globally heterogenious color distribution on Callisto had been detected from the Voyager spacecraft data [2]. There are wide areas including the large multi-ring structures Asgard and Valhalla which show a relatively steep spectral slope in the Voyager-wavelength range from 0.35 to 0.6 microns. Additionally some major areas, like a region south of Asgard, show less steep spectra at a regional scale. This area, together with Asgard, has been imaged by SSI and so both types of regions are included in the new dataset. Example spectra are given in *Fig. 2a*. *Fig. 3a* shows a color-ratio diagram with the 1MC/NIR (0.99/0.76) ratios displayed versus the VLT/NIR (0.42/0.76) ratios. The data points of the Asgard area and of equatorial latitudes (black symbols in *Fig. 3a*) show a rather linear distribution indicating the presence of two material end-members, presumably ice (towards the lower right corner in the diagram) and a major non-ice material.

Contrary to this, the measurement points of some dark areas at southern latitudes are much more scattered in the ratio diagram, preferentially towards higher 1MC/NIR values. An interpretation of this behavior is that there might be two different kinds of dark material located on the surface of Callisto, one (hereafter referred to as "mat.c1") rather uniformly distributed around Asgard and the equatorial regions, and the other ("mat.c2") locally mixed with "mat.c1" and ice in the southern regions. An independent support of this interpretation is the detection of slight absorption bands at 0.89 microns in several "mat.2"-type spectra (for an example, see *Fig. 2a*). None of the "mat.c1"-type spectra show indications for such a spectral feature.

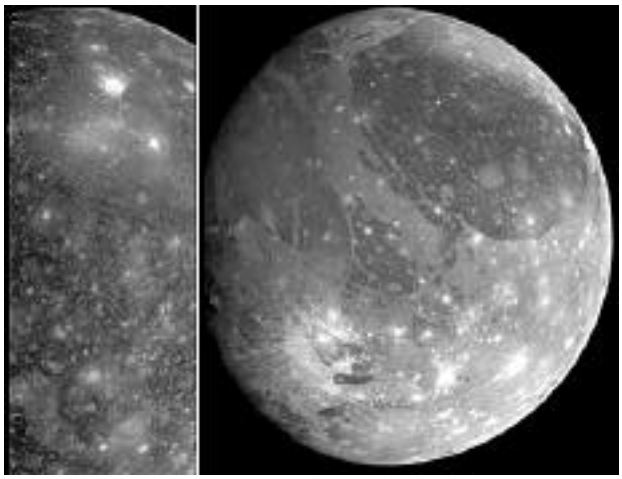

Fig. 1a (left) and 1b (right): Galileo violet filter images of Callisto (left) and Ganymede. For both satellites, VLT (0.42µm), GRN (0.56µm), NIR (0.76µm), MT2 (0.89µm) and 1MC (0.99µm) data are available. For Ganymede, an additional RED (0.66µm) partial frame with a resolution of 6.5 km/pixel has also been achieved.

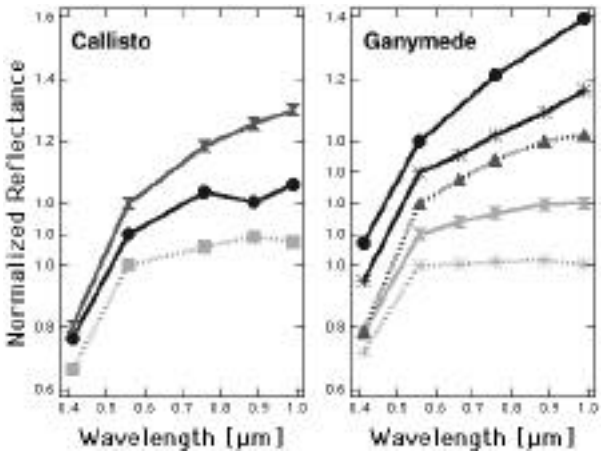

Fig. 2a (left): Callisto spectra. From top to bottom: Average equatorial material; dark southern material example; bright crater Tornarsuk.

Fig. 2b (right): Ganymede example spectra, from top to bottom: Dark floor crater material; "Osiris island"; part of Marius Regio; bright southern terrain; Osiris crater center. All spectra are normalized to 0.56µm.

GANYMEDE

Example spectra for Ganymede terrains are given in *Fig. 2b*. *Fig. 3b* shows the 1MC/NIR-vs.-VLT/NIR color-ratio diagram. Similar to Callisto (*Fig. 3a*) is the general trend of measurement-point distribution from the lower-right ("ice corner") to the upper-left. There is also no strong or even linear correlation between flat and steep spectra on Ganymede allowing a mixing by two end-member components, but different regions with similar VLT/NIR ratio values can show significantly different 1MC/NIR values. As for Callisto, at least three different end-member components can be modeled. Some examples in *Fig. 2b* show data of terrain with extreme spectral behavior.

The distribution of the measurement points between the three assumed end-members is more "blurred" than in the diagram for Callisto (*Fig. 3*). Spectrally closest to the southern material of Callisto ("mat.c2") are dark areas between the large impact structures Osiris (38°S, 170°W) and Gilgamesh (62°S, 123°W) (these areas are hereafter referred to as the "Osiris islands") and the dark floor material of the unnamed crater imaged during G2. The "Osiris-island regions" are also showing slight indications of absorption features at 0.89 microns, but these are less distinct than for "mat.c2" on Callisto. (For the dark crater, no 0.89-micron filter data are available.) Terrains with unusually low VLT/NIR ratios (dots "h" in *Fig. 3b*) are located near 30°N, 180°W including parts of Marius Regio, the southern ends of Nippur and Mashu Sulcus and the northern end of Uruk Sulcus, and a region around 20°S, 180°W (Marius Regio/ Sippar Sulcus). These areas show relatively low and uniform 1MC/NIR ratios and might contain the highest amount of a "mat.c1"-type material on this Ganymede hemisphere. The data indicate that this Ganymedian "mat.g1" might show even "more extreme" spectral characteristics (means lower 1MC/NIR values for VLT/NIR about 0.5) than the Callisto "mat.c1". Further analysis should clarify this.

Comparing the different terrains on Ganymede itself, there are hemispheric differences in the amount and distribution of the three components. The "Osiris islands" (dots "a" in *Fig. 3b*) and the dark floor crater (b) are close to a "mat.g2" end-member, whilst very bright craters (c) like Osiris (d) contain the "purest" ice. The southern bright terrain (e), as well as the north polar region (e), are preferrably mixed by ice and "mat.g2", containing only few of "mat.g1". On the other hand, the whole Uruk Sulcus area (f) and its eastern equatorial continuation up to the limb of the image appears to be composed mostly by a mixture of the "mat.g1" and ice. Galileo Regio (g) shows a mixture between "mat.g1" and "mat.g2" with a north-south trend of the mixing ratio and also variations in the ice amount.

DISCUSSION

The finding of three different kinds of spectral signatures for ice and non-ice components on Ganymede and Callisto leads to the question about their physical nature and origin. It might be possible that the different non-ice end-member materials are similar on Ganymede and Callisto. Regarding their physical nature, one possibility is that grain-size effects of the ice and one non-ice component might be considered as main reasons for the observed differences. Material differences — as stated above — might be another explanation. For example, the slight absorption at 0.89 microns in "mat.c2"-type spectra indicates that siliceous material should be responsible for the spectral behavior of this end-member. On the other hand, for "mat.1", the total lack of this feature and the much steeper ("redder") slope from 0.55 microns up to longer wavelengths indicates that different kinds of silicates or even organic components might be included.

References: [1] For detailed color analysis of the dark-floor crater, see also P. Helfenstein *et al.*, this volume. [2] T.V. Johnson *et al.*: Global Multispectral Mosaics of the Icy Galilean Satellites. JGR 88, B7, 5789–5805, 1983.

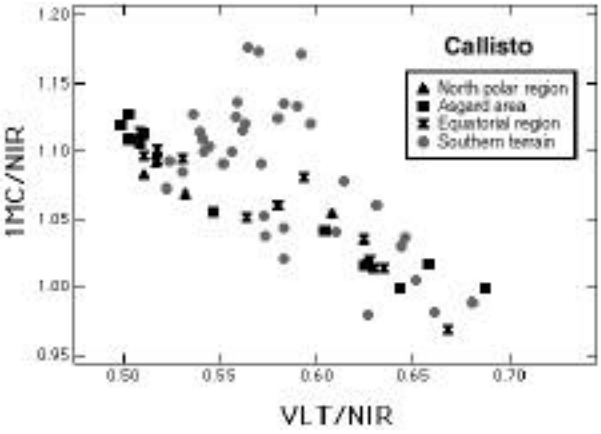

Fig. 3a: Color-ratio diagram, Callisto.

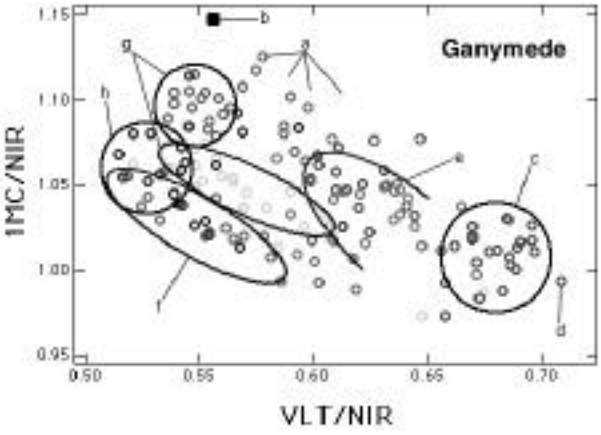

Fig. 3b: Color-ratio diagram, Ganymede. a="Osiris islands"; b=dark floor crater; c=bright spots and bright terrain; d=Osiris crater; e=southern bright terrain, north polar area; f=Uruk Sulcus and western terrain; g=Galileo Regio; h=Marius Regio.